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AN ECOLOGICAL CLASSIFICATION OF THE VEGETATION OF CEDAR POINT.

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The peninsula of Cedar Point, forming for seven miles a narrow barrier between the marshes and open waters of Sandusky Bay on the west and Lake Erie on the east, is probably by far the best place in Ohio for the study of ecology, either with respect to the adaptation of the plants to their environment, or to the aggregation of different species of plants into associations of various kinds, or the successional development of these various associations.

During the summer months of 1903 the writer, acting in capacity of Assistant to Dr. W. A. Kellerman, devoted his entire time to the preparation of a herbarium of the flora of Cedar Point and, in 1905, while acting as Instructor at the Lake Laboratory, the peninsula was again thoroughly explored and considerable study was made of the ecological phases of the subject. In 1906 and again in 1907 several days were spent on the peninsula, mainly in taking notes and in perfecting previous classifications of the vegetation, and it is believed that a fairly correct general ecological classification can now be presented of the vegetation of Cedar Point.[1]

This rather brief *reconnaissance* is given in the hope that it may be of use to other students of the flora of Cedar Point, serving as a basis for future more detailed and comprehensive work along ecological lines. Excellent opportunities are presented at Cedar Point for exact instrumental studies of the various habitats and it is to be hoped that the future may see this accomplished.

1. The author would here take the opportunity of gratefully acknowledging the various courtesies extended to him by Prof. Herbert Osborn, Director of the Ohio State University Lake Laboratory, and also the assistance rendered by Mrs. O. E. Jennings in the preparation of the illustrations for this article.

The shores of ponds, lakes, and oceans have been the subject of ecological studies to a greater extent than has any other physiographic region. This is, no doubt, due to the concentration in a small space of many different plant formations with the developmental stages exceptionally well defined. Studies of this sort of particular interest with respect to the ecology of Cedar Point, being physiographically quite similar as to the areas embraced, are those of MacMillan at the Lake of the Woods,[2] Cowles at the southern end of Lake Michigan,[3] Ganong at the Miscou Beach,[4] and Kearney at the Great Dismal Swamp,[5] and at Ocracoke Island.[6]

As referred to in the present article an association of species occupying a definite, more or less homogeneous unit of ecological environment (habitat), is termed an ecological plant *formation*. The formation is the unit of vegetation and is always characterized by one or more dominant species which are termed the *facies*. The facies may appear separately from each other, each having a definite association of accompanying species, and where this happens the facies thus characterize as many different *consocies*. Certain species in the formation may become very conspicuous at certain periods in the season (*aspects*), such species being termed *principal species* and the associations which they thus characterize, *societies*. The aggregation of the common descendants of a plant constitutes an ecological *family* and the aggregation of several families an ecological *community*.

All plant formations bring about reactions of various kinds in the habitat,—removal of plant foods, accumulation of vegetable debris, cutting off the light, etc.,—which usually result in making the habitat less suitable to the resident species but better suited to other species which, by *invasion* of the altered habitat, may eventually occupy it to the complete exclusion of the species of the original formation. Invasion consists (first) of *migration*, by which is meant the entrance into the habitat of disseminules of various sorts (seeds, spores, vegetative shoots, etc.), and (second) of *ecesis*, by which is meant the germination, growth, and establishment of the migrant disseminule.

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2. MacMillan, Conway. Observations on the Distribution of Plants along Shore of Lake of the Woods. Minnesota Botanical Studies. Geol. and Nat. Hist. Survey Minn. Bulletin 9 : 949-1023. 1897.

3. Cowles, H. C. The Ecological Relations of the Vegetation of the Sand Dunes of Lake Michigan. Bot. Gaz. 27 : 95-117, 167-202, 281-303, and 361-391. Feb., Mar., Apr., and May, 1899.
Also the Physiographic Ecology of Chicago and Vicinity. Bot. Gaz. 31 : 73-108, 145-182. Feb. and Mar., 1901.

4. Ganong, W. F. The Nascent Forest of the Miscou Beach Plain. Bot. Gaz. 42 : 85-87. 1906.

5. Kearney, T. H. A Report on a Botanical Survey of the Dismal Swamp Region. Contr. Nat. Herb. 5 : 367–395. 1901.

6. Kearney, T. H. The Plant Covering of Ocracoke Island. Contr. Nat. Herb. 5 : 275–284. 1900.

With the appearance of a new habitat, such as the elevation of a new land area, the initial formations will be *open*, i. e., not occupying the whole area; but, with successive changes in the habitat, often determined largely by reactions caused by the vegetation itself, the formations will become *closed*, and *competition* between the various species may become severe. From the *initial stages* the vegetation of a habitat will thus normally pass through a varying number of *intermediate stages* to an *ultimate* or *climax stage* in which the vegetation has reached a more or less permanent condition, termed *stabilization*.[7] Recent investigations have added considerably to our knowledge regarding competition between various species of plants and this has an important bearing upon the subject of succession between the various formations. It has been found that many plants throw off, or at least cause to be present in the soil certain substances toxic to themselves, to certain other plants, or to both.[8] Such phenomena alone could account for many ecological successions.

The ecological classification of the vegetation of a region is usually very intimately correlated with the physiography of that region, and the development of the vegetation through the successive stages of a succession is very often definitely determined by the corresponding land forms occurring in the physiographic development of the region. To this statement Cedar Point is no exception and the excellent work of Moseley in tracing the physiographic development of Cedar Point and Sandusky Bay is of great service to the student of the ecology of this region, in affording a foundation upon which to base an ecological classification of the vegetation. As a matter of fact, Prof. Moseley's publication includes much botanical matter directly in the line of an ecological classification, especially with reference to the vegetation of the sand ridges of the peninsula.[9]

The writer's extended investigations of the ecology of the peninsula of Presque Isle at Erie, Pennsylvania, during the last three years, and now in the course of publication, has led to a much better understanding of certain vegetational phenomena on Cedar Point. Presque Isle is considerably larger than Cedar

7. For an extended discussion of the various ecological processes and vegetational structures the reader is referred to Research Methods in Ecology, by F. E. Clements, Lincoln, Nebraska. 1905. In the present contribution the writer has followed Clements' terminology so far as technical terms have been used.

8. Livingston, B. E., Britton, J. C., and Reid, F. R. Studies on Properties of Unproductive Soils. U. S. Dept. Agr., Bureau of Soils, Bull. 28 : 1–39. 1905. Also Livingston, B. E., assisted by Jensen, C. A., Breazeale, J. F., Pember, F. R., and Skinner, J. J. Further Studies on the Properties of Unproductive Soils. U. S. Dept. Agr., Bureau of Soils, Bull. 36 : 1–71. 1907.

9. Moseley, E. L. Formation of Sandusky Bay and Cedar Point. Proc. Ohio State Acad. Science. Thirteenth Ann. Rpt. 4 : 179–238. June 15, 1905.

Point, the vegetation is almost entirely in its natural state, free from human interference, and some of the successions present a remarkably complete series of stages, whereas Cedar Point presents, in many cases, a fragmentary series considerably disturbed by man's activities.

With this explanation the writer in this contribution may, perhaps, be pardoned for frequent comparative references to the vegetation of Presque Isle. Although often differing considerably as to particulars, Presque Isle and Cedar Point have much in common, both with reference to the general physiographic development of the peninsulas and to the ecological classification of their vegetation.

The best method of treatment of the structure of the vegetation of any particular locality is, to be sure, more or less dependent upon the completeness of the successions. If the various stages of the successions are present it is most logical to use the developmental method, taking up the various stages in the order of their development and considering the vegetation as a gradual growth or evolution from the simple initial stages to the more complex stages tending towards stabilization.

The vegetation of Cedar Point will be discussed in this paper according to the developmental method, as many of the successional stages are exemplified, or at least indicated, in the present vegetation, while correlations with certain similar structures on Presque Isle will indicate the probable composition of certain missing stages.

The following classification is here presented as a provisional outline of the vegetational structures on Cedar Point. Wherever the same structure has been recognized both here and on Presque Isle the same nomenclature has been adopted as was used in the author's forthcoming work on the ecology of Presque Isle.

A—The Cottonwood Bar-Ridge-Thicket-Forest Succession.
- a—The *Populus-Salix* Dune Formation,
- b—The *Andropogon* Dune Formation,
- c—The *Toxicodendron* Thicket Formation,
- d—The *Pinus-Juniperus* Forest Formation,
- e—The *Quercus velutina-imbricaria* Forest Formation,
- f—The *Ulmus-Acer* Forest Formation.

B—The Lagoon-Marsh-Wet Meadow-Thicket-Forest Succession.
- a—The *Potamogeton* Formation, and
  The *Populus-Salix* Formation.
- b—The *Potamogeton* Formation, and
  The *Juncus-Eleocharis* Formation, and
  The *Populus-Salix* Formation.
- c—The *Potamogeton* Formation, and
  The *Typha-Scirpus* Formation, and
  The *Salix spp.* Formation, and
  The *Populus-Salix* Formation.

d—The *Potamogeton* Formation, and
The *Castalia-Nymphaea* Formation, and
The *Decodon-Persicaria* Formation, and
The *Cephalanthus-Cornus* Formation, and
The *Rhus-hirta* Formation, and
The *Ulmus-Acer* Forest Formation.

C—The Beach-Sand Plain-Thicket-Forest Succession.
a—The Lower Beach...The *Chlamydomonas* Formation,
b—The Drift Beach.....The *Cakile-Xanthium* Formation,
c—The Sand Plain .....The *Artemisia-Panicum* Formation,
d—The *Rhus-Prunus-Toxicodendron* Thicket Formation,
e—The *Quercus velutina-imbricaria* Forest Formation.

D—The Beach-Sand Plain-Heath-Forest Succession.
a—The Lower Beach...The *Chlamydomonas* Formation,
b—The Drift Beach.....The *Cakile-Xanthium* Formation,
c—The Sand Plain.....The *Artemisia-Panicum* Formation,
d—The Heath.....The *Arctostaphylos-Juniperus* Heath Formation,
e—The *Quercus velutina-imbricaria* Forest Formation.

E—The Dune and Blowout Successions.
a—The *Ammophila* Fringing-Dune Formation,
b—The *Elymus Dune* Formation, or
The *Andropogon* Dune Formation,
c—The *Prunus-Rhus* Dune Thicket Formation, or
The *Arctostaphylos-Juniperus* Heath Formation.

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a—The *Artemisia-Panicum* Blowout Formation,
b—The *Arctostaphylos-Juniperus* Heath Formation.
(The Secondary *Catalpa* Blowout Formation).

F.—The Bay-Marsh-Wet Meadow-Thicket-Forest Succession.
A. The Beach Habitat.
a—Same as under the Beach-Sand Plain-Thicket-Forest Succession.
B. The Marsh Habitat.
a—The *Scirpus* Formation,
b—The *Phragmites-Typha* Marsh Formation,
c—The *Salix discolor-lucida* Thicket Formation, or
The *Calamagrostis canadensis* Wet Meadow Formation,
d—The *Rhus hirta* Thicket Formation,
e—The *Ulmus-Acer* Forest Formation.
C. The Cove Habitat.
a— (The *Chara* Formation),
b—The *Potamogeton* Formation,
c—The *Castalia-Nymphaea* Formation,
d—The *Phragmites-Typha* Marsh Formation,
e—The *Calamagrostis canadensis* Wet Meadow Formation,

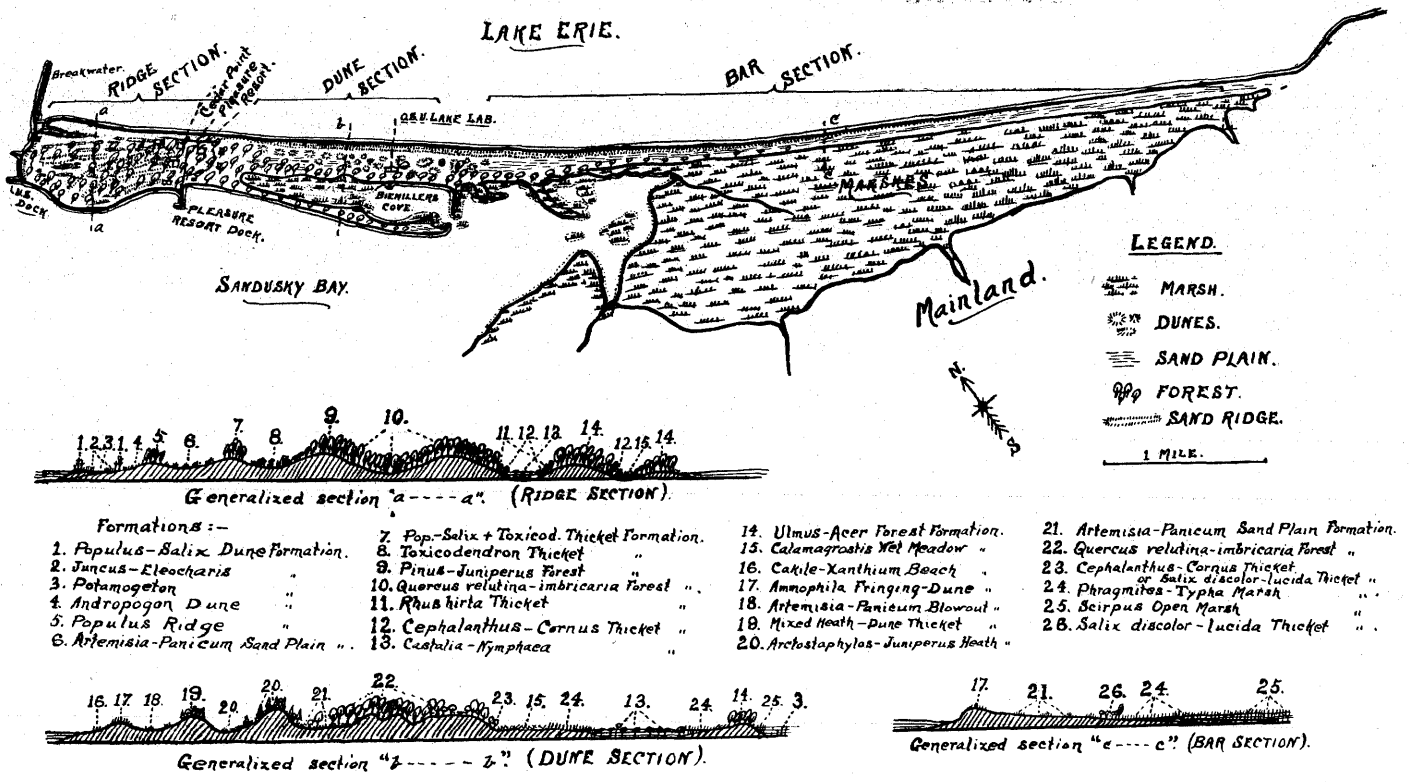

FIG. 1. Generalized ecological map and transects of Cedar Point. The width of the peninsula is relatively exaggerated to better show the vegetational features, and the finer topographic features are only approximately correct. For more accurate details of topography see Moseley's contribution and the U. S. Geolo. Survey Topographic Map.

f—The *Cephalanthus-Cornus* Thicket Formation,
g—The *Rhus hirta* Thicket Formation,
h—The *Ulmus-Acer* Forest Formation.
(The Anomalous *Ailanthus* Forest Formation).

THE COTTONWOOD BAR-RIDGE-THICKET-FOREST SUCCESSION.

As Prof. Moseley has so well shown, the terminal portion of Cedar Point, termed the Ridge Section, consists mainly of a series of sand ridges initiated by northeast gales during times of high water in Lake Erie, and subsequently built up to their present dimensions by the combined action of wind and vegetation in accumulating the loose beach sand. The approximate dates of formation of the ridges are shown to run consecutively from about 1429 A. D. for the oldest ridge, on the Bay side of the peninsula, to 1899 for the youngest ridge along the Lake front.

Beginning, therefore, with the present Lake Erie beach of the Ridge Section, the vegetation may be discussed from the developmental standpoint from the youngest to the older stages of the succession, the various stages being found in connection with similar physiographic units (sand ridges and intervening depressions) of consecutively older formation.

During a northeast gale, with high water in the Lake, the loose beach sand may be piled up into a bar which, upon the subsidence of the waves, will be left more or less permanently above the ordinary water level. Behind this bar there will be a more or less completely segregated lagoon. Into such a beach lagoon there will be blown during late spring many willow and cottonwood disseminules, which, floating upon the surface of the water, will soon be deposited and buried in the loose, wet sand which rapidly accumulates around the banks of the newly formed lagoon. Here the disseminules will sprout and the lagoon will soon be bordered by a zone of little cottonwoods and willows. The lagoon may be so narrow as to be completely filled up by the drifting sand before other vegetation may be able to establish itself, or, if the lagoon be wider, other vegetation may become established only to be later buried under the sand and killed. In either case, however, a sand rigde has been initiated by the establishment of the zone of cottonwoods and willows.

With the growth of the cottonwoods and willows there is offered an obstruction to the drifting sand, the height of the obstruction by its continued vertical growth tending to build the ridge ever higher. Cottonwoods will continue to grow vigorously under such conditions, providing the tops of the plants are not entirely buried. On Presque Isle the writer found cottonwoods buried to a depth of nearly 30 feet and still vigorously growing. As the lower branches of the tree become buried in the sand they die, although for a long time serving the purpose

of sand binders, and numerous roots are sent out from all portions of the buried trunk.

The initial stage of the succession under discussion may be designated as follows:

The *Populus-Salix* Dune Formation.

Facies: *Populus deltoides*,
Salix cordata (?).

Secondary Species:
Cakile edentula, *Salix interior*,
Ammophila edentula.

FIG. 2. Looking southward along the west side of sand ridge between the summer cottages and Lake Erie, north of the Breakers Hotel. Note the *Populus* forming the backbone of the ridge and the *Ammophila* and *Salix* being rapidly buried.

The rapidly growing ridge along the Lake front north of the Breakers Hotel is a fine example of the young stage of this formation. (Ridge No. 8, Moseley). With the vertical growth of the ridge the willows are soon buried and then probably the cottonwoods alone will not be able to offer a sufficient obstruction to the sand to cause further vertical growth of the ridge. In fact the branches immediately above the top of the ridge may die and the sand, being thus exposed to the action of the wind, may be again blown away. Generally, however, there appears another plant which, to a certain degree, takes the place of the lower limbs of the cottonwoods or, upon the death of the trees, may itself preserve the integrity of the ridge. The vegetational structure at this stage may be termed as follows:

The *Andropogon* Dune Formation.

Facies: *Andropogon furcatus.*

Secondary Species:

Artemisia caudata, *Andropogon scoparius,*
Panicum virgatum.

The development of this formation on Cedar Point is far inferior to its development at Presque Isle. On Cedar Point the formation is usually more or less mixed with the foregoing formation, as in parts of Ridge 7, and later passes into the following structure:

The *Toxicodendron* Thicket Formation.

Facies: *Toxicodendron pubescens.*

Secondary Species:

Populus deltoides, *Celastrus scandens,*
Parthenocissus quinquefolia, *Rhus aromatica,*
Quercus velutina, *Fraxinus americana,*
Salix amygdaloides, *Vitis vulpina,*
Ptelea trifoliata, *Andropogon furcatus,*
Poa compressa, *Juniperus virginiana.*

This formation is characterized by several lianas or semi-lianas, which, together with young trees of several species, constitute a more or less definite thicket formation above which stand the older cottonwoods. The last named species is here probably best regarded as a relict of the earlier formations. The *Toxicodendron* Thicket Formation is best exemplified on Ridges 6(1) and 6(2), (Moseley).

The *Pinus-Juniperus* Forest Formation.

Facies: *Juniperus virginiana,*
Pinus strobus.

Principal Species: *Vagnera stellata.*

Secondary Species:

Quercus velutina, *Quercus imbricaria,*
Toxicodendron pubescens, *Tilia americana,*
Populus deltoides, *Fraxinus americana,*
Fraxinus biltmoreana, *Salix amygdaloides,*
Platanus occidentalis, *Ulmus fulva,*
Opuntia humifusa, *Cyperus schweinitzii,*
Celastrus scandens, *Rubus procumbens,*
Asclepias tuberosa, *Arabis laevigata,*
Prunus serotina, *Rhus aromatica,*
Panicum scribnerianum, *Smilax herbacea,*
Equisetum robustum.

The exact status of this formation is not easy to determine with respect to its counterpart on Presque Isle, but it appears that the formation on Cedar Point is a sort of merging of what has been called two distinct formations on Presque Isle. The formation is typically exemplified on Ridges 5 and 4 and, in places, on 3.

No alternation is evident between the facies of this formation, but there is, however, a distinct layering; the following layers being evident:

1. Primary Layer.—The facies and other trees of larger size.
2. Secondary Layer.—Young trees, mainly of same species as the facies but relatively larger numbers of oaks.
3. Tertiary Layer.—Low shrubs and herbs; *Vagnera*, *Equisetum*, etc.
4. Ground Layer.—Represented very sparingly by occasional fleshy fungi, moulds, myxomycetes, etc.

The formation is characterized by one principal species constituting the *Vagnera stellata* Society. Also conspicuous community and family groups of *Equisetum*.

The *Quercus velutina-imbricaria* Forest Formation.

Facies: *Quercus velutina*,
Quercus imbricaria.

Principal Species: *Aralia nudiflora*,
Washingtonia claytoni.

Secondary Species:

Pinus strobus,
Tilia americana,
Prunus virginiana,
Smilax herbacea,
Rubus nigrobaccus,
Vitis vulpina,
Vagnera stellata,
Meibomia dillenii,
Galium circaezans,
Ulmus americana,
Monarda fistulosa,
Phryma leptostachya.
Juniperus virginiana,
Prunus serotina,
Fraxinus americana,
Toxicodendron pubescens,
Aralia racemosa,
Parthenocissus quinqefolia
Vagnera racemosa,
Lespedeza violacea,
Helianthus strumosus,
Solanum nigra,
Nabalus albus,

This formation is best shown towards the north ends of Ridges 3 and 2. The habitat, although originally a xerophytic one with a pure sand soil, has become more and more mesophytic. The water-containing and water-retaining powers of the soil have been much increased by the accumulation of about three inches of humus which acts as a mulch, and also the same general effect is brought about by the continual rise of the water table coincident with the cumulative rise of water in the Lake.

FIG. 3. Looking northwest along path from rear of Breakers Hotel, vegetation transitional into the *Pinus-Juniperus* Forest Formation. Note old cottonwoods, young pines, junipers, and oaks, and numerous lianas; also conspicuous tertiary layer.

This formation constitutes a forest habitat quite different in several respects from that of the preceding formation. The primary layer being deciduous, and, as a whole, being largely composed of species (oaks) coming into leaf rather late in the season, and, even then, not casting a dense shade, the relative amount of insolation reaching the lower layers in the oak forest is quite large; much larger than in the *Pinus-Juniperus* forest. Due in a large measure, probably, to this relatively greater amount of insolation there are developed in the oak forest much more pronounced layers. The following layers are there evident, aside from the Primary Layer the Shrub and Herbaceous Layers being most important:

1. Primary Layer.—Composed of the facies and other large trees.

2. Secondary Layer.—Younger individuals of the species constituting the primary layer, together with a very few large shrubs and small trees. Not a well defined structure in the formation as represented on Cedar Point.

3. Tertiary or Shrub Layer.—Composed of bushes and shrubs together with a tangle of lianas and certain tall herbaceous plants:

Rubus nigrobaccus,	*Smilax herbacea,*
Aralia racemosa,	*Vitis vulpina,*
Parthenocissus quinquefolia,	*Prunus virginiana,*
Nabalus albus,	*Rhus aromatica,*
Toxicodendron pubescens,	*Helianthus strumosus,*
Agastache nepetoides,	*Steironema ciliatum,*

4. Herbaceous Layer. Exhibiting more or less alternation with the Tertiary Layer and often grading imperceptibly into it, being at the same time of about equal importance with reference to the formational structure. This structure is very largely composed of herbaceous perennials with well developed underground stems, "Geophytes,"—Raunkiaer.[10]

Washingtonia claytoni,	*Aralia nudiflora,*
Vagnera stellata,	*Meibomia dillenii,*
Lespedeza violacea,	*Galium circaezans,*
Galium triflorum,	*Phyrma leptostachya,*
Polygonum virginianum,	*Vagnera racemosa,*
Salomonia commutata,	*Monarda fistulosa.*

5. The Ground Layer. This indefinite and variable layer is characterized by a few fungi and mosses living on the humus and dead leaves.

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10. Raunkiaer, C. Types Biologiques pour la geographie botanique. Oversigt over det Kgl. Danske Videnskabernes Selskabs Forhandlinger, 1905 : 347–437.

Liberal translation into German by Dr. F. Fedde. In Aus de Natur. Oct. 1 & 15; Nov. 1 & 15; Dec. 1 & 15; 1907, and Jan. 1 & 15, 1908.

The *Ulmus-Acer* Forest Formation.

Facies: *Ulmus americana*,
Acer rubrum.

Secondary Species:

Fraxinus americana,	*Fraxinus lanceolata*,
Quercus velutina,	*Acer nigrum*,
Platanus occidentalis,	*Ostrya virginiana*,
Sambucus canadensis,	*Rubus occidentalis*,
Rubus nigrobaccus,	*Ribes cynosbati*,
Parietaria pennsylvanica,	*Parthenocissus quinquefolia*,
Lactuca floridana,	*Impatiens biflora*,
Helianthus decapetalus,	*Phytolacca decandra*,
Solanum nigrum,	*Galium triflorum*,
Boehmeria cylindrica,	*Botrychium virginianum*,
Campanula americana,	*Circaea lutetiana*,
Dryopteris spinulosa,	*Eupatorium ageratoides*.

The accumulation of humus in the soil of the ridge as well as the general rise of water in the Lake has brought about a gradual change towards mesophytic, or even hydrophytic, conditions so that this formation, as represented on Ridge No. 1, is practically the same as would be the formation derived upon the filling up of a hydrophytic pond or swamp by the accumulation of humus. In either case there is a rich humous soil with great capillarity and a high water table.

The formation as represented on Cedar Point is not of large area and it has, moreover, been much disturbed by man's activities, and no effort was made on the part of the writer to determine the minor formational structure.

THE LAGOON-MARSH-WET MEADOW-THICKET-FOREST SUCCESSION.

In the writer's studies on the ecology of Presque Isle there was found to be represented there a remarkable series of lagoons, these being evident in all stages from extreme youth to mature old age, so that the successive development of the lagoon vegetation was not difficult to decipher. On Cedar Point, however, the lagoons are few and the successional series is rather incomplete. Nevertheless, such stages as are in evidence show much similarity to corresponding stages on Presque Isle so that, by correlation, a fair idea may be gained of the probable structure of the lagoon vegetation for the missing stages.

For a lagoon or pond the normal tendency is to become filled with accumulating vegetable debris, the surrounding vegetation being arranged in concentric zones, each inner one more hydrophytic, and, with the accumulation of vegetable debris and the elevation of the respective habitats, there is a continual advance of all the zones towards the deeper central portion of the lagoon

or pond. On Cedar Point, however, the elevation of the habitat of the various zones due to the accumulation of vegetable matter must to some degree be counteracted by the general rise of the water table consequent to the cumulative rise of water in Lake Erie,—2.14 feet per century. It seems likely that, in some cases at least, the general movement may be reversed as to the concentric vegetational formations, so that they may move away from the central portion of the depression; thus, from habitats more hydrophytic to less hydrophytic ones.

At the northeast corner of Cedar Point sand is rapidly accumulating along the shore to the south of the Jetty Protection or Breakwater and a lagoon is now (1907) being segregated from the Lake near the old light-house building. There is at this place a considerable indrifting of organic drift debris of various sorts so that the vegetation shows somewhat more of an affinity to that of a humus marsh or pond than is usual in beach lagoons. The initial stage here appears from the studies given it (1905–7) to be essentially as follows:

Stage A.

a. *Potamogeton* Formation.
b. *Populus-Salix* Formation.

The *Potamogeton* Formation.

Facies: *Potamogeton pectinatus.*
Secondary Species:
Vallisneria spiralis, *Potamogeton natans*, *etc.*

The *Populus-Salix* Formation.

Facies: *Populus deltoides*,
Salix cordata.
Secondary Species:
Salix fragilis (?), *Salix lucida*,
Cakile edentula, *Strophostyles helvola*,
Xanthium commune.

This latter formation may be considered as identical with the beginning of a *Populus-Salix* Ridge Formation but, under the conditions leading to the development of a sand ridge, the willows soon disappear while, under the more uniform conditions leading through the different stages of a lagoon succession, the willows are relatively quite important.

In the lagoon succession at Presque Isle the second stage shows the following structure, this appearing to be typical also for the Cedar Point succession, although somewhat mixed in the lagoon under discussion:

Stage B.

a. The *Potamogeton* Formation.
b. The *Juncus-Eleocharis* Formation.
c. The *Populus-Salix* Formation.

In the older part of this lagoon the *Potamogeton* Formation shows little change from its structure in the youngest part of the lagoon, excepting that the constituent plants are larger and more numerous. At the edge of the water and extending a few inches up onto the wet sand is a zone which may be termed:

The *Juncus-Eleocharis* Formation.

Facies: *Juncus balticus*,
Eleocharis intermedia.

Secondary Species:

Cyperus rivularis,
Populus deltoides,
Salix lucida.
Roripa palustris,
Salix cordata,

There is but little change in the outer *Populus-Salix* zone in this stage, aside from the further growth of the individuals and the appearance of occasional ruderal species. In the oldest and most highly developed parts of the lagoon under consideration the vegetation is in the beginning of what may be termed Stage C, with the following structure:

Stage C.

a. The *Potamogeton* Formation.
b. The *Typha-Scirpus* Formation.
c. The *Salix* (*spp.*) Formation.
d. The *Populus-Salix* Formation.

In this stage there is again little change in the *Potamogeton* Formation, but in the shallow water near the shore, and also taking the place of the *Juncus-Eleocharis* Formation on the wet bank at the water's edge, there has appeared a new vegetational structure as follows:

The *Typha-Scirpus* Marsh Formation.

Facies: *Scirpus validus*,
Scirpus americanus,
Typha latifolia.

Secondary Species:

Sparganium eurycarpum,
Eleocharis intermedia,
Sagittaria latifolia,
Roripa palustris,
Castalia tuberosa.
Juncus balticus,
Scirpus atrovirens,
Alisma plantago-aquatica,
Potamogeton natans,

Among the secondary species are a few, —*Alisma*, *Roripa*, *Sagittaria*,—which are more typically representative of the humus swamp or marsh margin than of a beach lagoon and their presence here is to be regarded as due to the rather large amount of organic matter (drift debris) incorporated into the soil of the habitat. The vegetation of this formation catches considerable sand and contributes quite appreciably to the filling of the lagoon.

The facies exhibit a distinct alternation in the *Typha-Scirpus* Formation. On the wet bank, and extending out into the water to a variable depth of about a foot, is the *Scirpus americanus* Consocies, alternating here and there with the *Typha latifolia* Consocies, while beginning in 6 or 8 inches of water and extending out into the deeper water of the lagoon, is the *Scirpus validus* Consocies, the latter thus forming a zone in the deeper part of the habitat. In this consocies *Castalia* is beginning to appear in a few places in the deepest part and, providing the marsh formation does not build up the soil and advance too rapidly, there may soon be initiated a new formation between the *Typha-Scirpus* Formation and the *Potamogeton* Formation.

In the upper part of the *Typha-Scirpus* Formation, and extending up to the outer *Populus-Salix* Formation, there is a zone the status of which was not satisfactorily determined. This zone has been provisionally designated as follows:

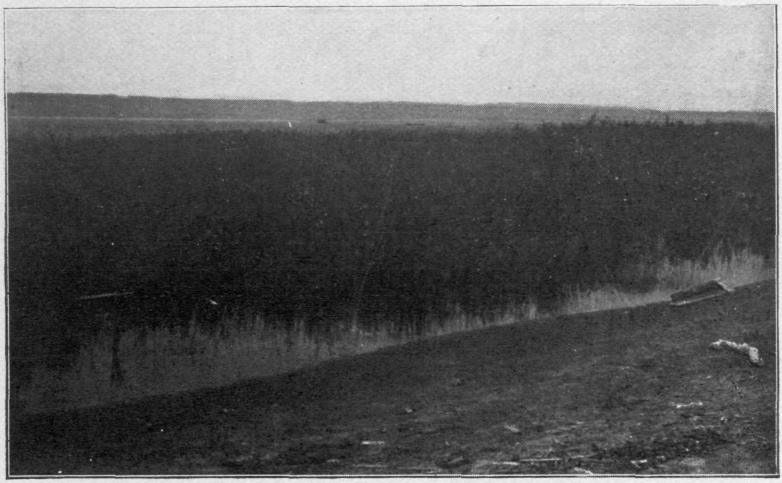

FIG. 4. Looking east across the new lagoon a few rods south of the Break-water. *Typha-Scirpus* Formation conspicuous. Lake in distance and bar visible just beyond the marsh vegetation. Young cottonwoods and willows in immediate foreground are submerged by unusually high water.

The *Salix* (*spp.*) Formation.

This structure probably represents a transitional condition the true status of which will become evident in the future. At present it consists of several species of *Salix* with scattering individuals of *Vitis vulpina*, *Bidens frondosa*, *Polygonum pennsylvanicum*, *Ambrosia trifida*, etc. The structure is evidently the beginning of a thicket formation similar in position to the *Myrica-Salix* thicket formation on Presque Isle.

Proceeding to the next oldest lagoon on Cedar Point we have the Lily Pond just to the west of the highest portion of Ridge No. 6. The present status of the vegetation around the pond is about that termed, for the succession on Presque Isle, stages "H" and "I". About the Lily Pond on Cedar Point the following general vegetational structure appears:

a. The *Potamogeton* Formation.
b. The *Castalia-Nymphaea* Formation.
c. The *Decodon-Persicaria* Formation.
d. The *Cephalanthus-Cornus* Thicket Formation.
e. The *Rhus hirta* Thicket Formation.
f. The *Ulmus-Acer* Forest Formation.

There should be in the deepest part of the pond a *Chara* Formation, but, for lack of the proper facilities for studying this vegetation this point was not determined. In similar ponds on Presque Isle there was evidence of a central *Chara* formation, although Pieters found in Lake St. Clair that this formation was usually scanty or entirely absent on a sandy bottom but present on a clay or alluvial bottom.[11]

The *Potamogeton* Formation.

This formation has here the following structure:

Facies: *Potamogeton pectinatus*,
Potamogeton natans.
Principal Species: *Utricularia vulgaris*.
Secondary Species:

Naias flexilis,	*Vallisneria spiralis*,
Philotria canadensis,	*Potamogeton sp.*

The *Castalia-Nymphaea* Formation.

This formation is perhaps relatively of more importance in the vegetational structure here than is the preceding formation. Its structure is essentially as follows:

Facies: *Castalia tuberosa*,
Nymphaea advena.
Secondary Species:

Potamogeton natans,	*Philotria canadensis*,
Utricularia vulgaris,	*Potamogeton sp.*,
Scirpus validus,	*Decodon verticillatus*.

This formation, relatively among its competitors, is a rapid soil-former. The plants of the formation typically exhibit large rootstocks, which upon their decay contribute considerably to the accumulation of humus, while the tangled mass of petioles and leaves in and on the water not only catch much floating debris, but, upon their decay, also add to the humus beneath.

11. Pieters, A. J. The Plants of Lake St. Clair. Michigan Fish Commission Bull. 2 : 6 and 9. 1894.

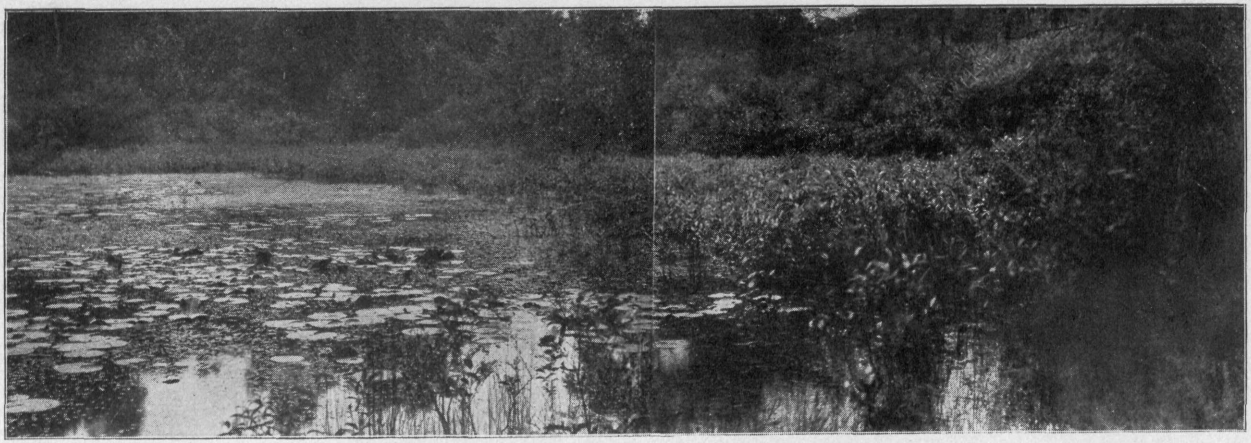

FIG. 5. Looking west across the northern part of the Lily Pond. Beginning at the left is the *Castalia-Nymphaea* Formation somewhat mixed with the *Potamogeton* Formation and consecutively to the right may be seen the *Decodon-Persicaria*, *Cephalanthus-Cornus*, *Rhus hirta*, and *Ulmus-Acer* Formations.

In the course of time the soil may have accumulated to such an extent that the shallower water may offer conditions suitable for other species than those of the resident formation and, by invasion and ecesis, another formation may eventually occupy the habitat. In the Lily Pond the formation next outside of the lily zone is the following:

The *Decodon-Persicaria* Formation.

Facies: *Decodon verticillatus*,
Persicaria laurina.

Secondary Species:

Naumbergia thyrsiflora,
Solanum dulcamara,
Pontederia cordata,
Nymphaea advena.
Alisma plantago-aquatica,
Cephalanthus occidentalis,
Sagittaria latifolia,

Further study of this formation might, perhaps, result in the placing of *Persicaria laurina* as a principal species, but it probably is best regarded as one of the facies. The *Decodon-Persicaria* Formation forms soil quite rapidly and upon the emergence of the soil above the ordinary water level the following structure takes possession:

The *Cephalanthus-Cornus* Thicket Formation.

Facies: *Cephalanthus occidentalis*,
Rosa carolina,
Cornus stolonifera.

Secondary Species:

Salix lucida,
Salix cordata,
Lathyrus palustris,
Typha latifolia,
Calamagrostis canadensis,
Persicaria laurina,
Alisma plantago-aquatica,
Scirpus americana,
Eleocharis intermedia,
Lathyrus palustris.

Towards the southern end of the pond there is a patch of wet meadow constituting a remnant, probably, of a once somewhat larger *Calamagrostis* Wet Meadow Formation. The latter formation is represented on Presque Isle by the strong *Cladium-Calamagrostis* Wet Meadow Formation, which, on lagoon banks with gentle slopes and correspondingly wide habitat zones, constitutes an important formation following the rushes and preceding the thicket stage . *Cladium* does not appear on Cedar Point but the *Calamagrostis canadensis* Wet Meadow Formation, really a consocies only of the northward-ranging *Cladium-Calamagrostis* formation, is well developed in the Cedar Point marsh succession and will be discussed further under that head.

In the *Cephalanthus-Cornus* Thicket Formation there is usually more or less of a mixture of the facies but sometimes a more definite structure is evident. Where there is a segregation

of the facies into definite structures the *Cephalanthus occidentalis* Consocies occupies the part of the habitat adjoining and grading into the *Decodon-Persicaria* habitat, while the other two facies alternate with each other in the outer more mesophytic part of the habitat. The formation is here bordered by a shrub formation which is approaching old age and which may more properly be regarded as a bordering thicket associated normally with the *Calamagrostis* Wet Meadow Formation.

The Rhus hirta Thicket Formation.

Facies: *Rhus hirta.*
Secondary Species:

Cornus amomum,	*Cornus stolonifera,*
Salix cordata,	*Salix nigra,*
Salix amygdaloides,	*Salix lucida,*
Vitis vulpina,	*Parthenocissus quinquefolia,*
Dryopteris thelypteris,	*Rubus nigrobaccus.*

This formation apparently displaces the *Salix* (*spp.*) Formation where dryer and more mesophytic conditions are approached. This also represents a consocies of a more northern formation which on Presque Isle was of considerable importance and was there designated as the *Rhus-Alnus* Thicket Formation.

The *Ulmus-Acer* Forest Formation.

There are evidences that this formation will come in instead of the *Quercus velutina-imbricaria* Forest Formation in the zone first occupied by the *Populus-Salix* Formation. The elevation of the water table and the consequent hydrophytic tendency of this habitat probably has something to do with the exclusion of the oak forest from this zone. Where the cotton-woods have built up a steep ridge in close proximity to the water, as on the east side of the Lily Pond, the vegetation will, of course, be more xerophytic and will follow the stages as indicated for the ridge succession, finally passing into the oak forest and this will not pass into the *Ulmus-Acer* forest until considerably more mesophytic or even semi-hydrophytic conditions prevail by the accumulation of much humus or by the rise of the water table, or both.

To the southwest of this pond there is a small narrow pond almost choked up with vegetation, the whole being somewhat further developed in its successional stages. The *Cephalanthus-Cornus* Thicket Formation is strongly developed and, in the course of a few years, unless the rise of the water is too rapid, the shrubs will have occupied the whole central portion of the depression.

Previous to the construction of the artificial canals or "Lagoons" in connection with the amusement features of the pleasure

resort there were other lagoons between the ridges in advanced stages of the lagoon succession, mostly in the thicket and forest stages although the rise of the water seems to have brought about marsh conditions in places. These older lagoons were not much studied as to the structure of their vegetation before they were destroyed by the dredging out of the artificial canals.

To the left of the path leading to the Eastland Dock and not far from the outlet of the artificial "Lagoons" is a small depression which is interesting in that it represents a secondary pond or lagoon succession. The rise of water in the Lake has finally brought about the rise of the water table into the bottom of a depression which was formerly dry land and there will accordingly follow in due time, the displacement of the present *Ulmus-Acer* forest by a secondary hydrophytic succession.

FIG. 6. Depression between outlet of "Lagoons" and the path to the Eastland Dock.

The present vegetation in and immediately around the water is as follows:

Primary Layer:

Acer saccharinum, (*perhaps some A. rubrum*).....60%,
Ulmus americana.....15%,
Platanus occidentalis.....15%,
Fraxinus americana.....10%,
Fraxinus nigra, one small tree.

Subordinate Layers: Below the primary layer there appear to be only species from the lower layers of the surrounding forest formation, with the one exception that in the pond is con-

siderable *Lemna trisulca.* Around the borders of the pond is a vigorous growth of the following species from the adjoining forest formation:

Impatiens biflora,
Dryopteris spinulosa,
Dryopteris thelypteris,
Geranium robertianum,
Adicea pumila,
Washingtonia claytoni.

Back of the cottages near the Government Dock there is a swampy area which evidently represents advanced stages of the lagoon succession in a lagoon which must have been initiated during severe northwest storms in the Bay. The depression is long and narrow and runs almost at right angles to the general direction of the large sand ridges of the Ridge Section, and is very nearly parallel to the general direction of the shoreline of the Bay near by. The vegetational structure of this depression is approximately a *Calamagrostis* Wet Meadow Formation in the central portion and rapidly invading this area from the sides is the *Cephalanthus-Cornus* Thicket Formation, around which, and in many places in which, is a strongly developed *Rhus hirta* Thicket Formation.

THE-BEACH-SAND PLAIN-THICKET-FOREST SUCCESSION.

In the time intervals between the initiation of the great sand ridges on Cedar Point there was, evidently, a gradual accumulation of sand along the beach of the Ridge Section of the peninsula, causing an outward growth of the land form without the building up of ridges, or, if ridges were initiated by the cutting off of lagoons, the sand drifted in from the adjoining land and from the new beach to such an extent that the lagoons were soon filled, the final result being, in either case, a level expanse of sand plain elevated but a few feet above the level of Lake Erie.

A considerable portion of Cedar Point consists of what may be called Sand Plain. This habitat comprises: (a), the level expanses between the ridges of the Ridge Section; (b), the main part of the Bar Section; and (c), a large proportion of the Dune Section, including also the more or less transitional portion of the peninsula between the Dune Section and the Ridge Section where part of the amusement tents and trinket stands of the Pleasure Resort are located. It is very difficult at times to draw more than an arbitrary line between sand plain and dune, especially in the Dune Section; both these physiographic structures owe their elevation above Lake level to the accumulation of wind drifted sand and differences of topography rather than of origin must be taken into consideration when an attempt is made at classification.

The Lower Beach—The *Chlamydomonas* Formation.

Following in part Cowles' classification[12] of the beach habitats, there may be distinguished, first, the Lower Beach,[13] comprising that part of the beach washed by the waves of ordinary summer storms and thus, chiefly by reason of the mechanical violence of the waves and the instability of the sub-stratum, practically devoid of plant life. However, as Cowles noted along the lower beach of Lake Michigan and as the writer found also on the Lower Beach of Presque Isle, a species of *Chlamydomonas*, a one-celled motile alga, occasionally occurs so abundantly in the sand as to cause a distinctly green coloration. These plants are perhaps more correctly to be regarded as migrants from the waters of the Lake, but, being so abundant in certain wet periods and being also the only plant found commonly in the habitat, we have termed the formation the *Chlamydomonas* Formation.

The Drift Beach—The *Cakile-Xanthium* Formation.

Extending from the upper limit of the waves of ordinary summer storms, i. e., the upper edge of the Lower Beach, up to the upper limit of the waves of severe winter storms, there is a zone which may be termed the *Drift Beach*,[14] which is characterized ordinarily by freedom from the violence of the waves of summer storms but is subjected to severe mechanical action of the waves of winter storms, at which time there is usually left a line of driftwood which marks, through the following season, the upper extent of the wave action.

The habitat as thus characterized is inhabited by a vegetation composed of such annuals as can endure the summer environment, the seeds having been left in their present position by wave action. Perennials and biennials are, of course, barred from this habitat by the destructive effects of wave action during the winter. The habitat presents above the surface of the sand conditions of excessive insolation, great and often very sudden extremes of temperature, great fluctuation in the water content of the air, and, also, high winds, and is thus distinctly xerophytic. The edaphic conditions are, however, distinctly hydrophytic below the surface layer of sand so that the habitat may, as a whole, be designated as dissophytic.[15] The vegetation

12. Cowles, H. C. The Ecological Relations of the Vegetation of the Sand Dunes of Lake Michigan. Bot. Gaz. 27 : 95–117, 167–202, 281-303, and 361–391. Feb., Mar., Apr., and May, 1899.

13. Cowles, H. C. l. c. Bot. Gaz. 27 : 114–117.

14. MacMillan's "Mid-strand" (Lake of the Woods); Schimper's "Mid-shore"; Cowles' "Middle Beach" (Lake Michigan); Ganong's "New Beach" (Miscou Island); are all synonyms for the habitat here designated as the Drift Beach.

15. See Clements—Research Methods in Ecology.

here consists, then, of dissophytic annuals, constituting as determined by the facies the *Cakile-Xanthium* Formation:

Facies: *Cakile edentula,*
Xanthium commune,[16]
Polanisia graveolens.

Principal Species: *Strophostyles helvola.*

Secondary Species:
Cenchrus tribuloides, *Euphorbia polygonifolia.*

There is considerable alternation in this formation, the *Cakile edentula* Consocies occupying the more exposed Lake beach, while the *Xanthium commune* Consocies is best seen in places along the less exposed Bay beach. *Polanisia* is more indifferent as to its location, it occurring sometimes alone but more usually indiscriminately mixed with the other facies.

The Sand Plain—The *Artemisia-Panicum* Formation.

Where the continuity of the outward growth of the land form of the peninsula has not been broken by the formation of a sand ridge it is often difficult to draw the line between the upper limit of the Drift Beach and the lower limit of the Sand Plain.[17] Upon the burial of the driftwood which accumulates in the upper part of the Drift Beach by the indrifting of sand, the land becomes sufficiently elevated to form a slightly different habitat which is, of course, free from the mechanical violence of the waves at any time, other than at very rare periods. The habitat thus may support a vegetation of annuals, biennials, and perennials, depending simply upon their ability to cope with the otherwise severe conditions of environment.

The vegetation of the Sand Plain may, from its facies, be designated as the *Artemisia-Panicum* Formation. It has essentially the following structure:

Facies: *Artemisia caudata,*
Panicum virgatum.

Principal Species:
Salix interior & var. wheeleri.
Arenaria serpyllifolia,
Arabis lyrata.

16. This species is probably best denominated as *Xanthium commune*, rather than as *X. canadense*, as given in the Flora of Cedar Point.—W. A. Kellerman and O. E. Jennings. Ohio Nat. 4 : 186–190. June, 1904.

17. Synonymous habitats with this are Macmillan's "Back Strand" (Lake of the Woods); Cowles' "Upper Beach" (Lake Michigan); and Ganong's "Grass Plain" (Miscou Island).

Secondary Species:

Opuntia humifusa,	*Oenothera oakesiana,*
Oenothera biennis,	*Andropogon furcatus,*
Asclepias syriaca,	*Panicum scribnerianum,*
Cyperus schweinitzii,	*Arabis canadensis,*
Euphorbia polygonifolia,	*Apocynum cannabinum,*
Acerates viridiflora,	*Ceratodon purpureus,*
Asclepias tuberosa,	*Cladonia sp.*

Species belonging more properly to other adjoining formations are as follows:

Quercus velutina,	*Quercus imbricaria,*
Ptelea trifoliata,	*Rhus aromatica,*
Toxicodendron pubescens,	*Arctostaphylos uva-ursi,*
Polanisia graveolens,	*Strophostyles helvola.*

The willow appears in places to dominate the formation during a good part of the growing period and under such conditions may de designated the *Salix interior* Society. Over limited areas of the older and more protected parts of the Sand Plain the *Arenaria serpyllifolia* Society and the *Arabis lyrata* Society characterize quite conspicuous vernal aspects.

The minor structure of this formation requires much further study. Especially after a careful instrumental determination of the environmental characteristics of the various parts of the habitat, a considerable modification might be found necessary. Among the more prominent characters displayed among component species of the formation may be mentioned the relatively large proportion of biennials and perennials. The formation during the hot portion of the summer is subjected to extremely severe and xerophytic conditions, at least during short periods, and it is probably to this that the structure af the vegetational formation is due. The formation is essentially an open structure and often displays prominent ecological families and communities as, for instance, with *Opuntia humifusa, Asclepias tuberosa,* etc.

Certain instrumental observations were made in parts of the sand plain during the summer of 1905 as to temperature, relative humidity, etc., and, as showing the extremely xerophytic conditions to which the plants of the sand plain are exposed at times, the following records may be of interest. On a day in middle August, 1905, in one of the open spaces between the advance guard of the oak forest north of the Laboratory where the slight breeze was so faint as to be inappreciable, the temperature of the air at a height of 1½ feet was 83 degrees Fahrenheit, while the sand at the surface just beside one of the communities of *Opuntia humifusa* was 142 degrees, taken at 1:30 P. M., while the maximum temperature for the day reported by the U. S. Weather Bureau

Station at Sandusky, about three miles distant across the Bay was 79 degrees, Fahr. (At 1 inch above the surface of the soil the air was 118 degrees; at 6 inches. 89; at 12 inches 84,—thermometer properly shaded.)

Thus far the vegetational structure in the succession under consideration has been comparatively uniform over the entire Sand Plain wherever the latter may be situated on the peninsula, but the *Artemisia-Panicum* Formation may be invaded and eventually succeeded by a formation having distinctly northern phytogeographical relationships, or, on the other hand, the succeeding formation may be one of more southern affinities.

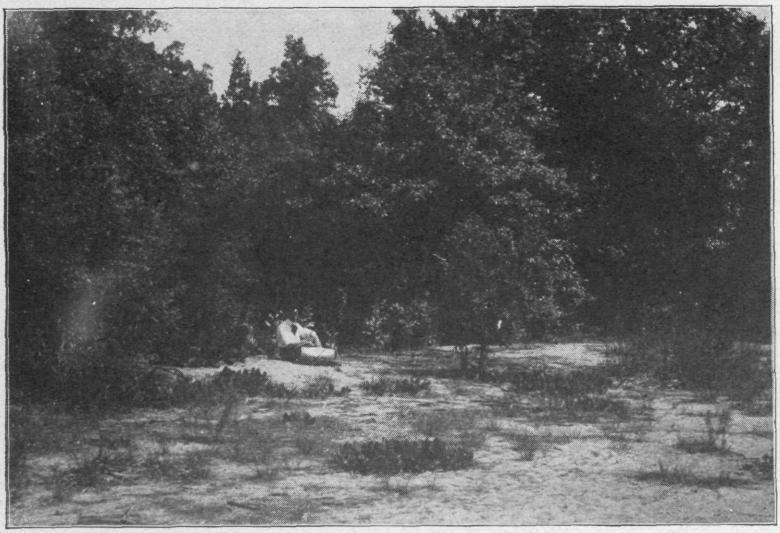

FIG. 7. Small area of Sand Plain enclosed by *Quercus velutina* and *Q. imbricaria*, *Celtis occidentalis*. Note communities of *Opuntia humifusa* with scattering *Artemisia*, *Panicum virgatum*, *P. scribnerianum* and *Verbascum thapsus*.

In the work on Presque Isle the writer found a considerable difference in both the habitat and in the corresponding vegetation in different portions of the Sand Plain such that two formational series could be distinguished as early in the succession as the Drift Beach. On Cedar Point, however, there are no such evident distinctions early in the succession but the critical period appears to be in the sand plain stage.

Accordingly, the succeeding vegetational structures with a more southern phytogeographical relationship will first be taken up, after which the structures of northern affinities will be dis-

cussed. The final decision as to the influences determining whether the one or the other phytogeographical element shall predominate must be deferred until exact instrumental determinations may have been made of the various environmental factors in the different parts of the Sand Plain, but, if an opinion may be here ventured, it seems probable that the ecological conditions are so nearly equally suitable for the two elements that historical considerations become of prime importance, and that a very slight fluctuation of the ensemble of ecological factors from one direction to the other may be sufficient to determine which vegetation shall gain the ascendency.

The vegetation of the Bar Section, as so well described by Moseley consists almost entirely of the *Artemisia-Panicum* Sand Plain Formation, there being on the Bay side a narrow strip of more hydrophytic vegetation just at the edge of the marsh. The whole bar is shifting over onto the marsh and it appears likely that the conditions do not reach such a state of stability as to permit the development of a well market thicket stage. Instead of an outward growth of the land form towards the Lake there is here exactly the opposite taking place and the real succession of habitats is abnormal, being from marsh through sand plain to beach.

At the south end of the small peninsula between Biemiller's Cove and the Bay there is a small area of the *Artemisia-Panicum* Formation, but there is no very well marked area of sand plain of any considerable size in the Dune Section, small areas being scattered here and there between the dunes and blow-outs and in the oak forest. Between the Dune Section and the Ridge Section are limited areas of a thicket stage which may be called the

Rhus-Prunus-Toxicodendron Thicket Formation.

The apparent facies being:
Rhus aromatica,
Prunus virginiana,
Toxicodendron pubescens.

This thicket formation is soon followed by the

Quercus velutina-imbricaria Forest Formation,

this having here essentially the same structure as described for the Ridge Succession. The thicket formation succeeding the *Artemisia-Panicum* Formation on Cedar Point is not nearly so prominent or vigorous a structure as is the corresponding *Myrica* Thicket Formation of Presque Isle.

Taking up now the succession of northern phytogeographic affinities we have, as follows:

THE BEACH-SAND PLAIN-HEATH-FOREST SUCCESSION.

This is the more common succession on the Cedar Point sand plain where the habitat is of several years duration. It is doubtful, if this succession were introduced onto the Bar Section, that it could reach maturity. In the Dune Section the heath and forest stages are essentially identical with the dunes and blowouts and, as the former often merge imperceptibly into the latter two formations the discussion of these stages will be taken up in connection with the discussion of the dune and blowout vegetation.

THE DUNE AND BLOWOUT SUCCESSIONS.

Under the above heading may be included a number of secondary formations which, taken together, make up most of the vegetation of the Dune Section of Cedar Point. As Moseley has pointed out,[18] this part of the peninsula represents a portion of the original mainland upon which has been heaped the loose sand, coincident with the rise of the waters of the Lake. There can be no doubt that the land was originally covered here with forest, probably an *Ulmus-Acer* forest formation, which later perhaps gave way to marsh vegetation but upon which, still later, has been heaped the loose sand bringing about conditions suitable for the present dune and blowout formations.

The *Ammophila* Fringing-Dune Formation.

Along most of the Lake shore of the Dune Section the Drift Beach extends up to a well-marked *Ammophila* fringing dune. This species of grass has the ability to grow upwards for a number of feet if continuously buried more deeply by accumulating sand and as the sand accumulates around the ever higher obstruction a gently sloping ridge is finally built up. The height of such a dune or ridge is determined by the height to which the grass can grow vertically, the amount of obstruction which it offers the drifting sand, and, finally, the force of the wind which tends to tear the dune down again.

The structure of the *Ammophila* Fringing-Dune Formation is quite simple:

Facies: *Ammophila arenaria.*
Principal Species: *Psilocybe ammophila.*
Secondary Species:

Euphorbia polygonifolia,	*Andropogon scoparius,*
Artemisia caudata,	*Strophostyles helvola,*
Cakile edentula,	*Panicum virgatum,*
Salix interior.	

18. Moseley, E. L. l. c. pp. 220–223.

During certain damp periods the agaric appears quite abundantly and can quite appropriately be designated as a principal species characterizing the *Psilocybe ammophila* Society and determining a summer aspect of the formation. The secondary species as may be noticed, are all invaders from the drift beach in front or from the habitat behind the fringing-dune. The secondary species are never very abundant in the dune.

The successor to the fringing-dune is somewhat indefinite. The *Ammophila* apparently dies out as soon as deprived of freshly drifting sand and, in case the beach grows outwards, the grass dies out and the sand is blown away by the wind, or, in some cases other dune plants may successfully invade the dune and hold the sand in place. Among these latter may be mentioned *Elymus* and *Andropogon* and, to some extent, *Arctostaphylos*.

The *Elymus* Dune Formation.

Facies: *Flymus canadensis*,
Elymus striatus.

Secondary Species:

Euphorbia polygonifolia,	*Artemisia caudata*,
Andropogon scoparius,	*Panicum virgatum*,
Tilia americana,	*Arctostaphylos uva-ursi*.

This formation is quite well represented along the Lake shore to the south of the bathing pavilion of the pleasure resort and it there apparently occupies an old *Ammophila* fringing-dune which has been left somewhat inland by the outward growth of the land form at this place, so that the *Ammophila* has been deprived of freshly drifting beach sand and has died out.

The stage succeeding the *Elymus* Dune Formation is here a mixed formation in which *Tilia americana*[19] and *Juniperus virginiana* are prominent, this formation eventually giving way to the *Quercus velutina-imbricaria* Forest Formation.

The *Andropogon* Dune Formation.

Facies: *Andropogon scoparius*,
(*Andropogon furcatus* also to a limited extent.)

Secondary Species: The secondary species are here about the same as those in the *Elymus* Dune Formation and it is not improbable that these two so-called formations may represent simply consocies of one and the same formation. *Andropogon scoparius*, as is also the case with *Panicum virgatum*, often forms about the separate clumps little dunes sometimes reaching a height of a couple of feet, but these miniature dunes disappear with the death of the grass and do not pass by succession into other vegetational structures.

19. Cowles, H. C. l. c. Bot. Gaz. 27 : 361–367. The *Tilia* dunes are along parts of the Lake Michigan dune district an important feature.

The successor to the *Andropogon* Dune Formation may be one of several different structures. In the formation are often to be found invaders, of the following species: *Prunus virginiana, Juniperus virginiana, Parthenocissus quinquefolia, Arctostaphylos uva-ursi, Ptelea trifoliata, Toxicodendron pubescens, Tecoma radicans,* so that the succeeding stage may be expected to be either a heath or a thicket. The larger part of the vegetation in the middle of the Dune Section corresponds closely to the vegetation of Cowles' "Dune Complex" of the Lake Michigan dune

FIG. 8. A miniature dune formed about a clump of *Panicum virgatum,* in a large blowout to the north of the Lake Laboratory.

region, and the instability of the sand is here such that a genetic series of the formations is a very difficult problem. However, it appears to the writer that the following formation would normally succeed the grass dune formations in the vicinity of the Lake Laboratory:

The *Prunus-Rhus* Dune-Thicket Formation.

Facies: *Prunus virginiana,*
Rhus aromatica,
Ptelea trifoliata.

Principal Species: *Tecoma radicans.*

Secondary Species:

Gleditsia triacanthos,
Parthenocissus quinquefolia,
Juniperus virginiana,
Quercus velutina,
Panicum virgatum,
Andropogon scoparius,
Elymus striatus,
Asclepias syriaca,
Toxicodendron pubescens,
Celastrus scandens,
Prunus serotina,
Amelanchier sp.,
Vitis vulpina,
Artemisia caudata,
Rubus nigrobaccus,

The various dunes scattered about in this section of the peninsula exhibit considerable alternation as to the facies so that there may be distinguished the *Prunus virginiana* Consocies, the *Rhus aromatica* Consocies, and the *Ptelea trifoliata* Consocies. These three structures are, however, often mixed indiscriminately on the same dune.

FIG. 9. The Dune Section, looking southwards from the Lake Laboratory. To the left are the dunes and blowouts, between which and the Bay to the right is the forest strip, here mainly consisting of the *Ulmus-Acer* and *Ailanthus* formations. (Photograph by Prof. Herbert Osborn.)

One of the most noteworthy peculiarities of this vegetation is the relatively large percentage of lianas and it is, in many cases, due more to the presence of these plants than to the other vegetation that the integrity of the dune is preserved against the vigorous action of the wind. In fact it appears that many of the dunes were initiated by the lianas or at least held by them until the invasion of the shrubs was accomplished. Especially noticeable in this connection are *Vitis vulpina* and *Parthenocissus quinquefolia*.

If the shore line of the Dune Section were advancing towards the Lake there would in all probability be a corresponding advance of the *Quercus velutina-imbricaria* Forest Formation over the dunes towards the east but, as conditions are at present, there seems to be only in a few places any real advance made by the oak forest and, practically, a state of equilibrium may be said to exist as to this phase of the question.

FIG. 10. A dune controlled by the *Prunus virginiana* Consocies of the *Prunus-Rhus* Dune Thicket Formation. Note secondary species: *Juniperus virginiana, Asclepias syriaca, Panicum virgatum.* In blowout surrounding dune note *Panicum virgatum, Salix interior.* This dune appears in distance in left third of preceding illustration.

Towards the northern portion of the Dune Section the grass dune formations are followed by a formation consisting of evergreen shrubs with northern phytogeographical relationships, this formation being termed:

The *Arctostaphylos-Juniperus* Heath Formation.

This formation, once established on a dune, brings about more stable conditions than does the *Prunus-Rhus* Thicket Formation. The vegetation being evergreen the winter winds are obstructed much more than is the case with a deciduous dune vegetation and not only are more stable conditions brought about but more sand is deposited by the wind. The structure of this formation is as follows:

Facies: *Arctostaphylos uva-ursi*,
Juniperus virginiana.
Secondary Species:

Andropogon scoparius,	*Panicum virgatum*,
Lithospermum gmelini,	*Quercus imbricaria*,
Quercus velutina,	*Celastrus scandens*,
Toxicodendron pubescens,	*Parthenocissus quinquefolia*,
Rubus procumbens.	

The heath on Presque Isle with somewhat more northern conditions of environment is regularly followed by a white pine forest which, in turn, is regularly replaced by a black oak forest. On Cedar Point, however, the pine stage does not appear to inter-

FIG. 11. One of the park-like vistas in the *Quercus velutina-imbricaria* Forest Formation in the northern part of the Dune Section. *Juniperus* and *Celtis* with the oaks, the border thicket being of *Toxicodendron*, *Rhus aromatica*, *Prunus virginiana*, while in sand plain are *Panicum virgatum*, *P. scribnerianum* and *Lepidium virginicum*.

vene but the heath stage is directly followed by the *Quercus velutina-imbricaria* Forest Formation, typically as described under the Cottonwood Bar-Ridge-Thicket-Forest Succession. In the northern part of the Dune Section there appears to be some advance towards the Lake on the part of the oak forest, young oaks being quite common in the heath at some distance in advance of the mature trees.

The *Quercus velutina-imbricaria* Forest Formation, however, in this part of the peninsula is far from being a continuous closed forest but is interspersed here and there with areas of open sand plain, giving to the whole a park-like aspect.

The Blowout Formations.

With the formation of dunes by the piling up of sand around the vegetation, there is a tendency towards the deflection of the wind so that its abrasive effect is intensified in open areas in close proximity to the dune. The usual result of this is a hollowing out of the sand at such points, constituting thus a "blowout." Cowles in his work on the sand dunes of Lake Michigan has termed as "fossil beaches" such beach habitats as have been covered over with dune sand or sand plain and later exposed again by the drifting away of the sand.[20]

Fig. 12. In Sand Plain at edge of oak forest in northern part of the Dune Section. *Quercus imbricaria* here affords shelter under which many Juniper seedlings are in evidence. This will likely become in time a dune capped by Junipers.

Towards the northern part of the Dune Section the Blowouts are soon occupied by the *Arctostaphylos-Juniperus* Heath Formation as described for the dunes although here perhaps somewhat more vigorous than on the dunes; due perhaps, to the some-

20. Cowles, H. C. l. c. Bot. Gaz. 27 : 173–175. Fossil Beaches.

what more sheltered position. Among the secondary species are a few not found in the formation as it appears on the dunes. One plant of *Juniperus nana* appears here, this being probably the extreme southern range of the species, so far reported for America, excepting certain distinctly alpine stations.

In the vicinity of the Lake Laboratory there is a blowout vegetation of a distinctly different character from that of the heath occupying the blowouts farther to the north. Apparently due to the deciduous character of the dune vegetation in the southern part of the Dune Section the blowouts are more pronounced, and, in fact, the dunes are often completely destroyed by the undermining of the sand by a deep adjacent blowout.

FIG. 13. Juniper-capped dune to the north of the Laboratory. The blowout which includes some "fossil beach" has *Panicum virgatum, P scribnerianum, Andropogon, Salix interior, Lepidium virginicum.*

In many cases the sand has been blown away so that the former beach has been again exposed (fossil beach) and in one blowout to the south of the Laboratory there has been either a wind excavation below the normal Lake level or the water has risen into the bottom of a deep blowout, and there has been initiated there a small lagoon succession.

The blowout vegetation near the Laboratory may probably be best regarded as an extension of the *Artemisia-Panicum* Sand Plain Formation. The same facies are in evidence although the relative importance of the secondary species is considerably different. *Salix interior* and its variety *wheeleri, Euphorbia poly-*

gonifolia, and *Oenothera oakesiana* are here more important vegetational elements than they are in the true Sand Plain. The successional stages following such a blowout formation are not clear; generally with the constant shifting of the sand the blowout is filled up with sand before a succeeding stage can become of importance. Perhaps, as in the case of the heath, the oak forest may be able to take possession without the intervention of a thicket stage.

FIG. 14. Juniper-capped dunes north of the Lake Laboratory. The blowout has *Panicum*, *Andropogon*, *Artemisia*, *Salix interior*. At base of dune at extreme right is a small patch of *Arctostaphylos uva-ursi*'

To the north of the Laboratory a short distance the dunes are mostly capped by good sized Junipers and it is plainly to be seen (Figs. 13 and 14) that with the death of these plants the dunes will be quickly destroyed. This locality must in the not distant past have been occupied by an *Arctostaphylos-Juniperus* Heath Formation, but with some sort of a change in the environment the conditions have become such that the deciduous dune and blowout formations have advanced towards the north, the *Juniperus*-capped dunes thus being remnants of a former heath. Possibly the reproduction of Junipers under the protection of vegetation other than the heath, as in Fig. 12 under *Quercus imbricaria*, may be concerned prominently with such conditions.

In the immediate vicinity of the Laboratory there has been initiated a secondary *Catalpa* Blowout Formation by the planting of a considerable grove of Catalpa seedlings for commercial purposes, but, nevertheless, constituting an ecological experiment of more than passing interest. It is too early to yet predict as to the outcome but it appears probable that the trees will succeed if their roots can once become established in lower layers of sand with abundant and never failing ground-water near at hand. If successful and permitted to reach considerable size, dune formation will likely take place on a rather extensive scale and eventually, if allowed to run its course, the place would become an elevated more or less level area with a *Quercus velutina imbricaria* Forest Formation such as in the area now occupied by the buildings of the pleasure resort.

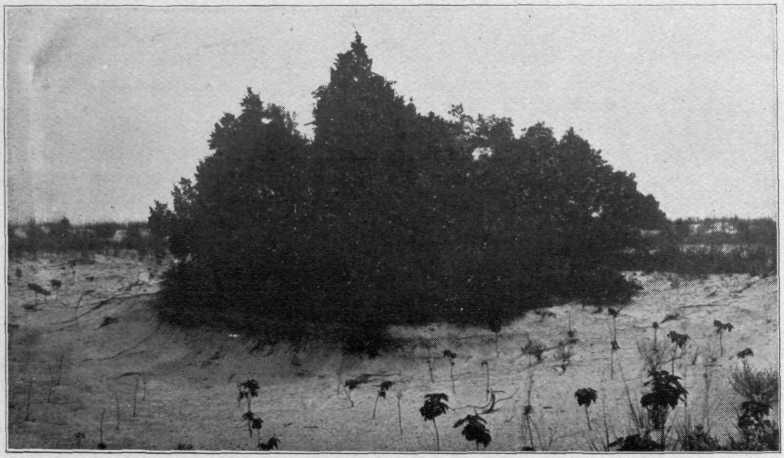

FIG. 15. Secondary *Catalpa* Blowout Formation showing dead plants where the sweep of the wind has induced excessive transpiration.

THE BAY-MARSH-WET MEADOW-THICKET-FOREST SUCCESSION.

Along the western side of the peninsula the vegetational structures represent a variety of conditions of environment which may be classed in a general way under three heads:

1. The Beach Habitat. This habitat includes those portions of the shore which are exposed fully to the action of the surf and from which the water deepens outwards with comparative rapidity.

2. The Marsh Habitat. This habitat comprises those portions of the shore which are comparatively free from the action of violent surf and from which the water deepens outwards from the land very slowly.

3. The Cove Habitat. This habitat comprises those portions of the Bay which are enclosed by peninsulas, etc., in such a manner as to be protected from the action of currents and surf, and in which the water is several feet at least in depth.

The Beach Habitat.

This structure is practically the same beach as is to be found along the Lake shore of the peninsula, although less strongly developed. It has also the same vegetational formations somewhat less well developed and so will not need here a separate discussion. This habitat comprises much of the western shore of the peninsula, northwards from the end of the small peninsula at the entrance to Biemiller's Cove.

The Marsh Habitat.

This structure is exceedingly well developed between the Bar Section of Cedar Point and the mainland to the south and west, embracing altogether hundreds of acres of pure marsh. From Moseley's researches it appears certain that portions of this marsh have remained marsh for hundreds of years, the accumulation of vegetable debris, transformed into muck, having been so nearly equal to the cumulative rise of water that the marsh vegetation has been able to successfully hold the habitat against all invaders for a very long period. It is further to be remembered that this area was formerly a part of the mainland and at one time covered with forest which was eventually killed by the rise of the water, the marsh then taking its place, perhaps an intervening thicket first appearing. The retarding of the currents of the streams entering the marsh at the present and the occurrence of marsh thickets and pure marshes along the retarded and widening stream are at present indicative of the method of origin of the marsh.

The structure of the vegetation in the Marsh Habitat may be analyzed thus:

a. The *Scirpus* Formation,
b. The *Phragmites-Typha* Marsh Formation,
c. The *Salix discolor-lucida* Thicket Formation,
or the *Calamagrostis* Wet Meadow Formation,
d. The *Rhus hirta* Thicket Formation,
e. The *Ulmus-Acer* Forest Formation.

The *Scirpus* Formation.

This formation is nearly related to the *Typha-Scirpus* formation of the Lagoon Succession but, as we have pointed out for Presque Isle, there is a separation of the two species of that formation when the conditions of the Marsh Habitat are attained. *Scirpus validus* and *Scirpus americanus* are morphologically so constructed as to have a life-form very little affected by surf,

the long, cylindrical, stiff, but yet quite flexible, stems being admirably adapted to withstand surf conditions in which the larger, less flexible leaves and stems of *Typha* with a greater surface exposed to the action of the surf, would be broken up and the plant killed. Accordingly we find that part of the marsh exposed to the action of the surf to have the following structure:

Facies: *Scirpus validus*,
Scirpus americanus.
Principal Species: *Dianthera americana*.

Within the formation there is a distinct zonation, the *Scirpus validus* Consocies occupying the deeper water, often to a depth of four or five feet, while the *Scirpus americanus* Consocies occupies the shallower portion of the habitat, often extending, where the bottom is sandy, out to the water's edge or even onto the wet bank, but on a muck bottom it is usually replaced in water a foot or less in depth by the formation next described. The action of the surf is considerably diminished by stretches of this formation and quite considerable quantities of shifting sand may be stopped and accumulated by the rushes, thus building up the land.

The *Dianthera americana* Society occurs in a few places in the habitat of the *Scirpus americanus* Consocies, being best developed on sand-bars or islands submerged a few inches and over which which there is usually more or less of a current,—practically the condition of a river sand-bar where this plant reaches its best development. The submerged bar along the south side of the entrance to Biemiller's Cove shows this Society very nicely.

With the accumulation of sand and the consequent shallowing of the water, often also with the accumulation of more or less well defined deposits of partially humified muck, the following formation succeeds the *Scirpus* Formation:

The *Phragmites-Typha* Marsh Formation.

Facies: *Typha latifolia*,
Phragmites phragmites.
Secondary Species:

Zizania aquatica,	*Scirpus americanus*,
Sagittaria latifolia,	*Persicaria laurina*,
Sparganium eurycarpum,	*Calamagrostis canadensis*,
Solanum dulcamara,	*Naumbergia thyrsiflora*,
Nymphaea advena,	*Dulichium arundinaceum*,
Lemna trisulca,	*Wolffia columbiana*,
Carex aquatilis,	*Carex comosa*,
Salix sp.,	*Cephalanthus occidentalis*,

Many of the secondary species of this formation are more or less temporary invaders belonging more properly to other formations. The larger part of the formation is made up of the

facies alone, the *Typha latifolia* Consocies being found in the deeper water and in perhaps more exposed positions than is the *Phragmites phragmites* Consocies.

The immense accumulation of muck underlying this marsh is likely the product of the accumulation and subsequent more or less complete humification of the remains of the plants of this formation. The annual growth of these plants constitutes a large quantity of vegetable matter which, upon its death, is placed in most favorable conditions for its retention and subsequent humification. In places where the accumulation of humus has been so rapid as to raise the level of the soil above the water or, as along the edge of the Bar Section, where sand drifts in and helps to build up the soil, there follows a succession by either the *Calamagrostis canadensis* Wet Meadow Formation or by the *Salix discolor-lucida* Thicket Formation.

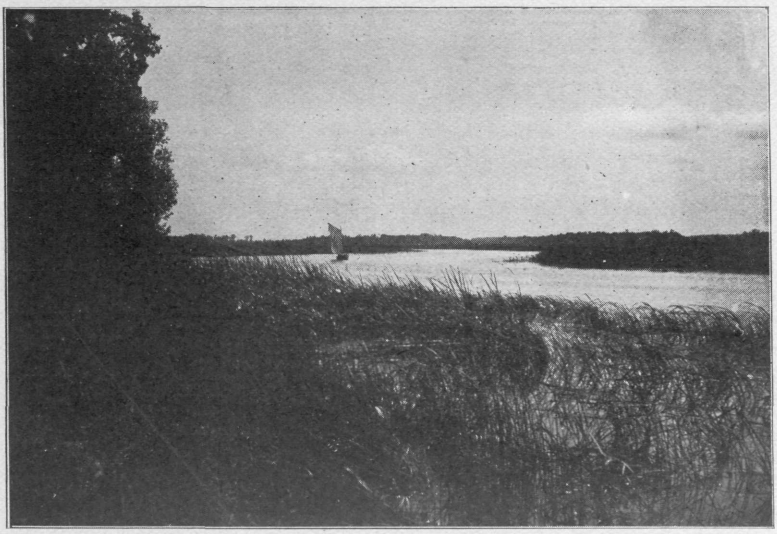

FIG. 16. The Black Channel and the *Phragmites-Typha* Marsh Formation. The forests in the far distance are at the edge of the mainland on the other border of the marsh more than two miles distant.

The *Salix discolor-lucida* Thicket Formation.

There are no very well marked examples of this formation and its structure is not clear to the writer. However, the structure has been correlated with a similar and well-marked formation at Presque Isle, and in the limited areas where it occurs along the Bar Section it agrees well with the Presque Isle formation. It possibly may prove to be the same structure as was called the

"*Salix sp.*" Formation around the lagoon at the northeast corner of the peninsula. As exemplified along the Bar the structure is as follows:

Facies: *Salix discolor*,
Salix lucida,
Salix amygdaloides.
Principal Species: *Solidago canadensis*.
Secondary Species:

Salix cordata,	*Lycopus americana*,
Cornus amomum,	*Cornus stolonifera*,
Rhus hirta,	*Rosa carolina*,
Cephalanthus occidentalis,	*Cicuta maculata*,
Epilobium adenocaulon,	*Mimulus ringens*,
Impatiens biflora,	*Stachys aspera*,
Teucrium canadense,	*Thaspium barbinode*.

The conditions of environment brought about by a rise in water level are such that xerophytic soil with little humus rapidly passes through the mesophytic to the hydrophytic stage and this is evidently not so well suited to the *Salix discolor-lucida* Thicket Formation as is a similarly situated, humus-rich soil, which, with the elevation due to the accumulation of vegetable humus has passed from hydrophytic to more mesophytic edaphic conditions, as is ordinarily the case around marshes and ponds.

In a few places this shrub formation alternates with the *Calamagrostis* Wet Meadow Formation, but, as this is of comparatively limited extent as compared with the wet meadow occurring in connection with the Cove Habitat near the Laboratory, a discussion of its structure will be taken up under the treatment of the Cove Habitat.

The *Rhus hirta* Thicket Formation.

This formation is sparingly developed along the marsh shore of the Bar Section but it is comparatively not vigorous and does not form areas of any considerable size. It sometimes borders the preceding shrub formation (*Salix discolor-lucida* Thicket Formation) or the wet meadow formation, or it may directly adjoin the *Phragmites-Typha* Marsh Formation. In many places there is a direct transition from the Sand Plain of the Bar Section to the Marsh Formation with no intervening shrub or meadow zone.

The cottonwoods in the Bar Section are not of great age and they have undoubtedly been such as have accomplished ecesis in the edge of the marsh where the disseminules were buried under the indrifting sand; conditions almost identical with those obtaining along the wet bank of a newly formed beach lagoon.

In a few places towards the Dune Section *Ulmus americana* seedlings were found along the shores of the marsh under such con-

ditions as would indicate a possible *Ulmus-Acer* zone as a successor to the shrub zone providing other conditions do not prevent their development. However, if the trend of environmental conditions is to continue indefinitely as in the past there is little probability that this forest zone will be able to mature.

The Cove Habitat.

The Cove Habitat and its vegetation is one of the most marked ecological features of Cedar Point. The completeness of the vegetational structure and the size of the habitat, as exemplified in Biemiller's Cove and in other coves to the south of the Laboratory, are far in advance of anything in this line at Presque Isle and to say the least, the student of cove vegetation will find here exceptionally fine opportunities for such studies. Proceeding from the deepest water towards the shores the general structure of the vegetation may be classified as follows:

a. (The *Chara* Formation.)
b. The *Potamogeton* Formation,
c. The *Castalia-Nymphaea* Formation,
d. The *Phragmites-Typha* Marsh Formation,
e. The *Calamagrostis canadensis* Wet Meadow Formation,
f. The *Cephalanthus-Cornus* Thicket Formation,
g. The *Rhus hirta* Thicket Formation,
h. The *Ulmus-Acer* Forest Formation.

The *Chara* Formation.

A few specimens of *Chara* were found at Presque Isle in situations similar to the Cove Habitat at Cedar Point and Pieters reports more or less complete *Chara* associations in the western end of Lake Erie and in Lake St. Clair, although seldom found where the bottom was sandy.[21] Probably with proper facilities a search of the coves of Cedar Point would reveal a more or less well developed *Chara* formation; although generally sandy, the cove bottoms are not altogether so.

The *Potamogeton* Formation.

This formation is particularly well developed here and, in general, it very closely resembles the corresponding formation at Presque Isle. Its habitat may be said to comprise that part of the cove in which the water is four feet or more in depth, excepting in the deepest portions where the *Chara* Formation may be more characteristic. The coves are likely nowhere so deep as to exclude the latter formation. The structure of the *Potamogeton* Formation is essentially as follows:

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21. Pieters, A. J. The Plants of Western Lake Erie with Observations on their Distribution. U. S. Fish Commission, Bull. 1901 : 57–79. and The Plants of Lake St. Clair. Bull. No. 2, Michigan Fish Commission, 1894.

Facies: *Potamogeton perfoliatus*,
Potamogeton lonchites,
Potamogeton pusillus.
Principal Species:
Vallisneria spiralis,
Myriophyllum spicatum.
Secondary Species:
Potamogeton natans,
Potamogeton amplifolius,
Naias flexilis,
Castalia tuberosa,
Scirpus validus,
Ceratophyllum demersum.
Potamogeton foliosus,
Potamogeton zosteriaefolius,
Philotria canadensis,
Nymphaea advena,
Nelumbo lutea,

FIG. 17. A *Pontederia cordata* Society along the submerged bar at the south end of Biemiller's Cove. The *Typha latifolia* Consocies of the *Phragmites-Typha* Marsh Formation in the background.

The mass of vegetation comprising this formation is altogether quite large and the water is often so thoroughly filled up with it that, looked at from above, the space appears completely taken up by the vegetation in the middle and lower depths. The conditions are very good for the accumulation of considerable deposits of vegetable debris and for straining out suspended sediments in the water, or for obstructing to some extent floating debris, so as to finally lead to its deposition on the bottom. Under conditions of stable equilibrium, as to the relative position of water level and the land, this formation could be expected

in the course of time to build up the bottom to such an extent as to eventually lead to the invasion and occupation of the habitat by the formation to be next described.

The *Castalia-Nymphaea* Formation.

This formation also is well developed in the Cedar Point coves. It occupies a zone next outside of the *Potamogeton* Formation in water of a depth of from one or one-and-one-half feet to four feet. In its outer deeper part it is always much mixed with the *Potamogeton* Formation but aside from that it is a well defined and vigorous structure.

Facies: *Castalia tuberosa*,
Nymphaea advena,
Nelumbo lutea.

Principal Species: *Pontederia cordata*,
Utricularia vulgaris,
Zizania aquatica.

Secondary Species:

Potamogeton natans,
Potamogeton pusillus,
Myriophyllum spicatum,
Sagittaria latifolia,
Naias flexilis,
Typha angustifolia,
Batrachium longirostris.
Potamogeton lonchites,
Bidens beckii,
Philotria canadensis,
Sagittaria graminea,
Typha latifolia,
Phragmites phragmites,

FIG. 18. The *Nymphaea advena* Consocies, here mingled with the *Castalia tuberosa* Consocies, in the second cove south of Biemiller's Cove. *Typha* in the immediate background and *Phragmites* farther back.

The facies of this formation exhibit more or less zonation. *Castalia tuberosa* generally forms a Consocies in the deeper part of the habitat of the formation while the shallower part of the formation often has alternating *Nymphaea advena* Consocies and *Nelumbo lutea* Consocies. Over a large part of the habitat, however, the facies are mingled to such an extent that the consocies structure is not evident.

The *Pontederia cordata* Society is not ordinarily of large extent but the plant usually appears in dense ecological families and communities. This Society is usually associated with the *Nymphaea advena* and the *Nelumbo lutea* Consocies in the shallower water of the habitat.

FIG. 19. The *Nelumbo lutea* Consocies mingled in the left background with the *Pontederia cordata* Society. The general background being the *Phragmites phragmites* Consocies of the Marsh Formation. In the third cove south of Biemiller's Cove.

The *Utricularia vulgaris* Society determines a quite conspicuous aspect in midsummer in some of the little bays and inlets opening off from the larger body of the cove into the marsh,—usually in water of not more than six or eight inches in depth with a deep semi-liquid muck bottom.

The *Zizania aquatica* Society determines a conspicuous autumnal aspect almost throughout the whole formation except, perhaps, in the very deepest part. During midsummer this

structure only begins to show, but at the fruiting season of the wild rice the habitat of the *Castalia-Nymphaea* formation is conspicuously dominated by the Society.

The *Phragmites-Typha* Marsh Formation.

In the more sheltered habitat afforded around the cove this formation differs from the formation as found in the marsh to the west of the Bar Section in that the *Typha latifolia* Consocies is more prominent. It appears from the writer's observations that the *Typha latifolia* Consocies prefers a soil rich in humus while the *Phragmites phragmites* Consocies, other conditions being

FIG. 20. The *Utricularia vulgaris* Society in one of the larger inlets running into the marsh at the north end of Biemiller's Cove. *Typha latifolia* and *Typha angustifolia* Consocies in the background. *Scirpus americana* at the right.

equal, prefers a more sandy substratum. On the submerged sand bar which forms the southern boundary of Biemiller's Cove the axis of the bar where about a foot under water is occupied by the *Phragmites phragmites* Consocies, while towards the junction of the bar with the mainland, where there is considerable humus in the soil, the *Typha latifolia* Consocies appears.

The composition of the formation as exemplified around the coves is as follows:

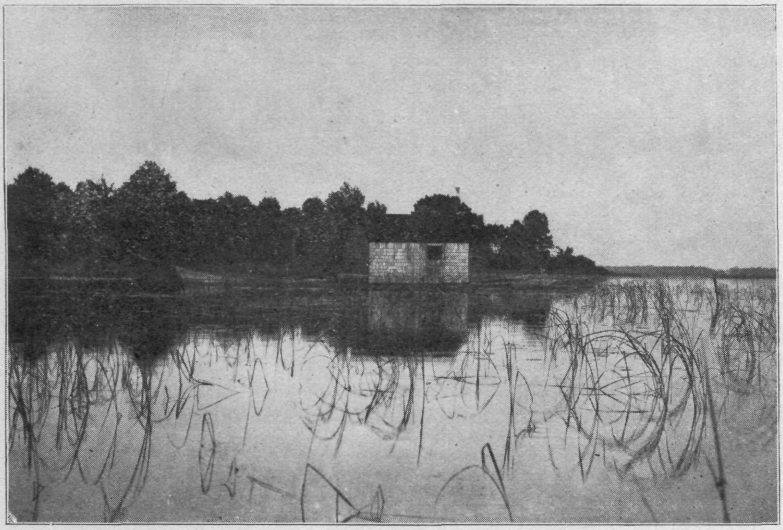

FIG. 21. In fourth cove south of Laboratory, photo taken in late August shows the *Zizania aquatica* Society beginning to appear.

FIG. 22. Looking northwest across the northern part of Biemiller's Cove and the adjoining marsh. *Castalia-Nymphaea* Formation at left in cove. *Typha latifolia* and *Typha angustifolia* Consocies comprise most of marsh. The narrow peninsula in distance occupied by the *Ulmus-Acer* Forest Formation. Photo taken from roof of Laboratory.

Facies: *Typha latifolia,*
Typha angustifolia,
Phragmites phragmites.
Principal Species: *Hibiscus moscheutos.*
Secondary Species:

Zizania aquatica,	*Dianthera americana,*
Sagittaria latifolia,	*Sparganium eurycarpum,*
Lemna trisulca,	*Dulichium arundinaceum,*
Naumbergia thyrsiflora,	*Persicaria laurina,*
Cornus amomum,	*Cornus obliqua,*
Cephalanthus occidentalis,	*Carex comosa,*
Cicuta maculata,	*Solanum dulcamara,*
Calamagrostis canadensis,	*Carex comosa.*

This formation, with the building up of the soil above the water level, may give way immediately to a shrub formation but, where there is a considerable extent of wet soil just above the level of the water, there is more likely to be an invasion and subsequent occupation by a wet meadow formation, as follows,—typically exemplified at the eastern border of the marsh to the north west of the Laboratory:

The *Calamagrostis canadensis* Wet Meadow Formation.

Facies: *Calamagrostis canadensis.*
Secondary Species:

Blephariglottis psycodes,	*Bidens discoidea,*
Boltonia asteroides,	*Campanula uliginosa,*
Carex schweinitzii,	*Carex comosa,*
Carex frankii,	*Carex lanuginosa,*
Carex stipata,	*Carex tribuloides,*
Carex bicknellii,	*Carex lupulina,*
Carex [illegible]iflora,	*Carex vulpinoides,*
Ceph[illegible]s occidentalis,	*Cornus amomum,*
Cornu[illegible]ua,	*Sambucus canadensis,*
Dryopt[illegible]helypteris,	*Epilobium adenocaulon,*
Lobeli[illegible]ilitica,	*Lathyrus palustris,*
Gyros[illegible]ernua,	*Mimulus ringens,*
Penth[illegible]sedoides,	*Onoclea sensibilis,*
Roripa[illegible]pida,	*Roripa palustris,*
Rumex [illegible]spus,	*Rumex verticillatus,*
Rumex obtusifolius,	*Salix cordata,*
Salix amygdaloides,	*Salix lucida, etc.*

The list of secondary species in this formation is a very long one, especially when including various invading species from the other formations adjacent, and certain other more or less ruderal species. However, in the real vegetational structure these many species play very little part, the facies constituting almost entirely the bulk of the vegetation.

This formation is apparently a rather rapid soil former and with the elevation of the ground the more mesophytic conditions permit the entrance of the following thicket formation, as around the east side of the area of the *Calamagrostis* Wet Meadow to the northwest of the Laboratory:

The *Cephalanthus-Cornus* Thicket Formation.

Facies: *Cornus amomum*,
Cornus obliqua,
Cephalanthus occidentalis,
Rosa carolina.

Principal Species: *Sambucus canadensis*.

Secondary Species:

Salix cordata,
Salix lucida,
Polygonum convolvulus,
Dryopteris thelypteris,
Ailanthus glandulosa,
Rhus hirta.
Salix amygdaloides,
Calamagrostis canadensis,
Solanum dulcamara,
Platanus occidentalis,
Ulmus americana,

This vegetation should be classed rather as a mixed formation, perhaps, than as a pure one, it apparently being made up of various elements from the other thicket zones on the peninsula. The predominating consocies is the *Cornus amomum-obliqua* Consocies, while during the flowering period of the elderberry the *Sambucus canadensis* Society determines in places a conspicuous aspect.

Along the eastern shore of the marsh and wet meadow formations forming the northward extension of Biemiller's Cove, considerable sand has blown over in places from the peninsula and the bank rises in such places quite abruptly. [illegible]ch points the *Rhus hirta* Thicket Formation usually occup[illegible] more xerophytic habitat and it, evidently, under such [illegible]tions, is succeeded by the *Quercus velutina-imbricaria* F[illegible] Formation.

Where the slope is more gradual, with [illegible] hydrophytic soil, usually also with more humus, the norma[illegible]sion appears to be from the wet meadow through the *Ce*[illegible]*uthus-Cornus* Thicket Formation to the *Ulmus-Acer* Forest [illegible]ation.

The *Ailanthus glandulosa* Forest Formation.

An interesting example of an anomalous succession is afforded in the near vicinity of the Laboratory and at a couple of other stations on the peninsula by the *Ailanthus glandulosa* Forest Formation which is rapidly developing along the shores of the cove and Bay in the Dune Section. This Asiatic ruderal tree now constitutes a prominent zone occupying the habitat of the less hydrophytic of the thicket zones, although often displacing

also the *Cephalanthus-Cornus* zone and extending, as well, up the sides of adjacent dunes and onto the adjacent *xerophytic* Sand plain.

Although very successful in competition with the *Cephalanthus-Cornus* and *Rhus hirta* Thicket Formation, it appears probable that this formation will eventually be succeeded by the *Ulmus-Acer* Forest Formation. The structure of the *Ailanthus glandulosa* Forest Formation, as to the lower layers, is intermediate generally between that of the thicket formations that have been supplanted and that of the *Ulmus-Acer* forest. A number of the species, such as *Campanula americana*, belong more especially to the latter formation, but the conditions of dense shade of the Ailanthus forest seem to have supplied the conditions essential for its entrance into this habitat.

Certain secondary successions are to be seen in several places on Cedar Point, as brought about by the agency of man, but these were not studied in detail by the writer. One of these successions has been brought about by the effort made to have a lawn and shrubbery in the vicinity of the buildings of the Pleasure Resort. Another secondary succession marked by the appearance of a number of ruderal species has been brought about by the throwing aside of sand in connection with the dredging of the artificial "Lagoons."

Carnegie Museum, January 20, 1908.